April 17, 1856.

The LORD WROTTESLEY, President, in the Chair.

The following communications were read :—

I. " On the Condition of the Oxygen absorbed into the Blood during Respiration." By GEORGE HARLEY, M.D., Teacher of Practical Physiology and Histology in University College, London. Communicated by Professor SHARPEY, M.D., Sec. R.S. Received March 16, 1856.

(Abstract.)

The author commences by explaining, that his researches were instituted with the view of ascertaining whether the doctrine maintained by Magnus in regard to the gases interchanged in the lungs during respiration were correct—namely, that the gases in question enter into *no* chemical combination with the constituents of the blood, either in passing to or from the tissues and organs of the body, but form merely a physical mixture with the circulating liquid. The principal object of the inquiry was to determine the following points :—

1. Has blood the property of chemically combining with the respired oxygen ?

2. Which of the constituents of the blood enter into combination with oxygen ?

3. Do these constituents, by combining with oxygen, simply become oxidized, or do they also yield carbonic acid gas ?

4. What are the agents which control these changes ?

After describing the method of investigation, and the apparatus employed, the author proceeds to relate a few of the analyses which he considered as the most conclusive. Instead of confirming the view of Magnus, that gases enter into no chemical combination with

blood, his results led him to conclusions of an opposite character, which serve to confirm the more generally received doctrine.

In one set of experiments a certain quaintity of fresh ox-blood was first shaken with renewed portions of air until it had become thoroughly saturated with oxygen, then introduced into a graduated glass vessel with 100 per cent. of ordinary air, corked carefully up, and kept during twenty-four hours in a room of moderate temperature. In order to favour the mutual action of the air and blood, the vessel was frequently agitated. At the expiration of twenty-four hours the gas was analysed by Bunsen's method. In an example cited the following was found to be its composition :—

Oxygen.....	10·42	total oxygen.. 15·47
Carbonic acid	5·05	
Nitrogen	84·53	
	100·00	

On comparing this with the composition of the common air (oxygen 20·96 ; carbonic acid 00·002 ; nitrogen 79·038) which had been introduced into the vessel, it is seen that 10·54 per cent. of oxygen has disappeared, while 5·05 per cent. of carbonic acid now exists, where only a trace of its presence could before be detected.

Similar results were obtained with defibrinated blood. In a case where defibrinated arterial blood from a calf, after complete saturation with oxygen, was kept in contact with an equal volume of air during twenty-four hours, and treated exactly as in the previous example, the gas on analysis yielded in 100 parts,—

Oxygen.....	11·33	total oxygen=17·29
Carbonic acid	5·96	
Nitrogen	82·71	
	100·00	

showing in this case also that the air which had been imprisoned during twenty-four hours along with blood, no longer possessed its original composition, but that some of its constituents had been materially increased, while others had diminished in a manner no less marked.

It would appear from these examples that the blood had probably become oxidized in two ways ; first, by giving off a quantity of car-

bon, and secondly by directly combining with oxygen. As to the portion of oxygen which has disappeared, and which is not accounted for by the carbonic acid evolved, it may have combined partly with another portion of carbon, to form a limited amount of carbonic acid, which by the law of absorption is retained in the blood; and partly with hydrogen or some other oxidable constituent of the blood, without yielding a gaseous product.

These two experiments it will be observed point to exactly the same conclusions, and together with a number of others, where the mode of procedure was similar, and which were attended with similar results, have satisfied the author as to the fallacy of Magnus's doctrine, "that the oxygen received during respiration into the blood is kept there merely by the law of mechanical absorption, and enters into no chemical combination with that liquid." Had this assertion been well-founded, such a change as has been seen to occur, in the composition of the air enclosed along with blood, saturated as the blood already was with oxygen, could not have happened.

After having ascertained that air underwent certain changes in composition during its contact with blood, it next became an object to discover by which of the constituents of the blood these changes were induced. With this view the author successively subjected the organic compounds of the blood separately to the action of air, by a similar process to that adopted in the case of the blood itself.

A certain quantity of fresh fibrin, moistened with water, was saturated with oxygen, placed in a receiver along with eight volumes of air, and kept during twenty-four hours at a temperature of from 20° to 25° cent. At the expiration of this time the gas on analysis was found to have the following composition:—

Oxygen.....	6·81	total oxygen.. 17·98
Carbonic acid	11·17	
Nitrogen	82·02	
	100·00	

thus showing that fibrin takes up a certain quantity of oxygen, and gives off a stated amount of carbon combined with oxygen in form of carbonic acid gas.

The next experiments were made upon albumen, but as that substance could not be obtained in a pure, and at the same time un-

coagulated state from blood, the albumen of the hen's egg was employed, which possesses very similar characters. It was found that when a certain quantity of the white of the hen's egg was well saturated with oxygen, and afterwards kept in contact with an equal volume of air during a certain number of hours at a temperature of 36° cent., the gas on analysis gave in 100 parts,—

Oxygen	17·05
Carbonic acid	2·09
Nitrogen	80·86
	100·00

proving, in common with the experiments on the blood and on fibrin, that albumen also possesses the property of absorbing oxygen and disengaging carbonic acid.

Some comparative experiments were also made upon serum and upon blood-coagulum, in which it was found that the air confined along with the serum yielded on analysis—

Oxygen	16·74
Carbonic acid	2·30
Nitrogen	80·96
	100·00

while that confined with the coagulum contained—

Oxygen	8·57
Carbonic acid	7·29
Nitrogen	84·14
	100·00

It thus appears that the oxygen exerted a much more powerful action on the coagulum, which contained the fibrin and blood-corpuscles, than on the serum, which contained only albumen. The experiment thus corroborated the results previously obtained with pure fibrin and pure albumen. The pure fibrin was seen to produce a much greater change in the composition of the atmospheric air than the pure albumen from the hen's egg. The difference in the case of the coagulum and the serum was so much marked, that the author felt anxious to find out whence it proceeded; and under the impression that the hæmatin in the corpuscles might have mainly contributed to

the result (as other organic colouring matters possess the property of absorbing oxygen and giving off carbonic acid gas), he took a small quantity of pure blood-hæmatin prepared by Verdeil's process, and put it into a vessel along with 1000 volumes of ordinary air. After the air had been kept in contact with the hæmatin for some months, the gas was analysed and found to contain—

Oxygen	16·01
Carbonic acid	3·80
Nitrogen	80·19
	100·00

The pure colouring principle of the blood, therefore, by exposure to ordinary air, gives off carbonic acid gas, and becomes oxidized in two ways; first by a loss of carbon, and secondly by direct combination with oxygen. The author considers that this last result furnishes additional evidence of the correctness of an opinion he hazarded two years ago*, imputing to the colouring matters of the vegetable and animal economy a more important office in the function of respiration than they before had been considered to possess, and regarding their principal function in organized beings as the absorbing of oxygen and exhaling of carbonic acid—a view altogether irrespective of Liebig's well-known hypothesis, which assigns the above office to the iron of the blood-hæmatin.

The author concludes by expressing the hope that his experiments will be considered as at least serving to establish one important fact respecting which further evidence was wanted, namely, that the entire volume of the respired oxygen is not transmitted in an uncombined state (as Magnus believes) to the various organs and tissues of the body, but that a portion of it enters into chemical combination with some of the organic constituents of the blood.

* Verhand. Physik-Medizin. Gesellsch. zu Würzburg, Bd. v. 1854; and Erdmann's Journ. f. prakt. Chemie, Bd. lxiv. H. 5. 1855.